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YIIFSWA
Yams for Livelihoods

Working with farmers to produce clean seed yams

Nora McNamara and Stephen Morse

YIIFSWA Working Paper Series No. 5 2014

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Preface

The YIIFSWA (Yam Improvement for Income and Food Security in West Africa) project is an R4D project of IITA. The project is funded by the Bill & Melinda Gates Foundation and executed in Nigeria and Ghana by IITA in partnership with a consortium of national and international R4D agencies and in collaboration with service provider organizations, the private sector, farmers, and yam traders.

The YIIFSWA project has the following broad objectives:

1. Strengthen small-scale farmer and trader market linkages, particularly in less accessible producing areas, to realize benefits from improved ware yam productivity and market demand.
2. Strengthen capacities and empower small-holder farmers in the yam value chain.
3. Establish sustainable availability of high quality seed yam on a commercially viable and price competitive bases in targeted areas.
4. Reduce postharvest losses and improve product quality.
5. Develop technologies for high ratio propagation of high quality breeder and foundation seed yam.
6. Evaluate and scale out yam production technologies with improved and local popular varieties.
7. Identify more effective prevention and management tools and strategies for pests and diseases.

Each objective is addressed by a team of researchers supported by other researchers working on two cross-cutting components, namely impact monitoring, evaluation and learning; and communication and information dissemination.

The YIIFSWA Working Paper Series is published informally by YIIFSWA to disseminate its intermediate outputs. Publications in the series include methodologies for, as well as preliminary results of the various objective teams of the YIIFSWA project. The series is aimed at scientists and researchers working with national agricultural research systems in West Africa, the international research community, policy makers, donors, and members of international development agencies that are interested in yam. As these papers are not in their final form, comments are welcome. Such comments should be addressed to the respective authors or to the YIIFSWA Project Manager.

Individuals and institutions may obtain copies by writing to:

The Project ManagerYam Improvement for Income and Food Security in West Africa
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Ibadan, Nigeria

1. Introduction

White yam (*Dioscorea rotundata*) is a major root crop grown throughout West Africa but especially in the more humid, southern parts of the region. Nigeria and Ghana are major centers of production in West Africa. The crop has high nutritional and economic value as well as being of significant cultural importance in many parts of this area. However, it is demanding of labor and good quality planting material is both scarce and expensive. However, despite its regional importance, yam has received relatively little attention from researchers and extension services relative to crops such as cassava and sweetpotato. The Bill and Melinda Gates funded project entitled “Yam Improvement for Income and Food Security in West Africa” (YIIFSWA) aims to address this gap.

An outline of the YIIFSWA project is set out in Figure 1.

One of the components of the YIIFSWA project (Objective 3) is geared to the promotion of clean seed yam production amongst smallholder farmers in Nigeria and Ghana. These revolve around the promotion of a technology developed from research funded by the UK's Department for International Development (DFID) between 2003 and 2005 and tested again in 2011 and 2012 for the production of clean seed yam without some of the risks and costs associated with other approaches (Morse et al. 2009; McNamara et al. 2012). This is now known as the Adapted Yam Minisett Technique (AYMT) and, as its name suggests, is an adaptation of the Yam Minisett Technique (YMT) developed and promoted from the late 1970s.

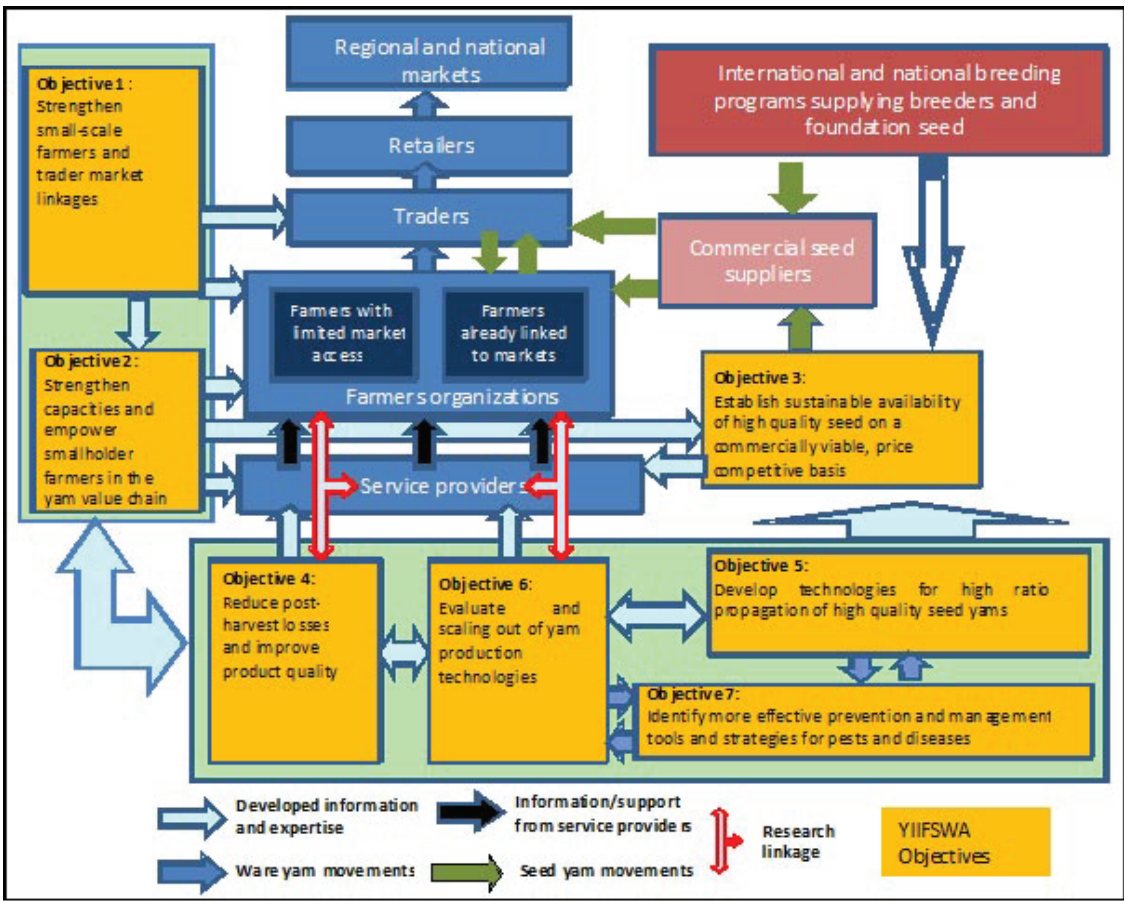

Figure 1. Schematic outline of the YIIFSWA project. (Source: YIIFSWA project proposal).

In the YIIFSWA project the AYMT is being promoted in a number of areas in Nigeria as illustrated in Figure 2. The three areas represent three distinct seed yam systems. The first is in the Federal Capital Territory (FCT) where the capital of Nigeria (Abuja) is located. This is a relatively highly urbanized and wealthy part of the country. The second is Agagbe, Benue State, located in one of the prime yam growing areas of the country—the Benue River basin. The third is close to the town of Idah in Igalaland (Kogi State) within the Niger River basin. The fourth is in Illushi (Edo State), where a major seed yam market that supplies ware yam growers throughout the River Niger basin is sited. Hence in Figure 2 the towns of Idah and Illushi are connected by shading. Ilushi is not the only specialist seed yam market in the Niger Basin, but one of the largest. The Niger and Benue River basin areas are not as highly urbanized as the Abuja area; neither is there the same degree of wealth (Benue and especially Kogi are amongst the poorest states in Nigeria). There are certain urban centers in Benue and Kogi States, especially the state capitals (Makurdi and Lokoja, respectively) but for the most part they are highly rural. A further distinction is that in the FCT and Benue farmers tend to use techniques such as milking and cutting of yam tubers into setts to serve their demand for planting material, while in the Niger River basin farmers opt to purchase their seed from specialist growers.

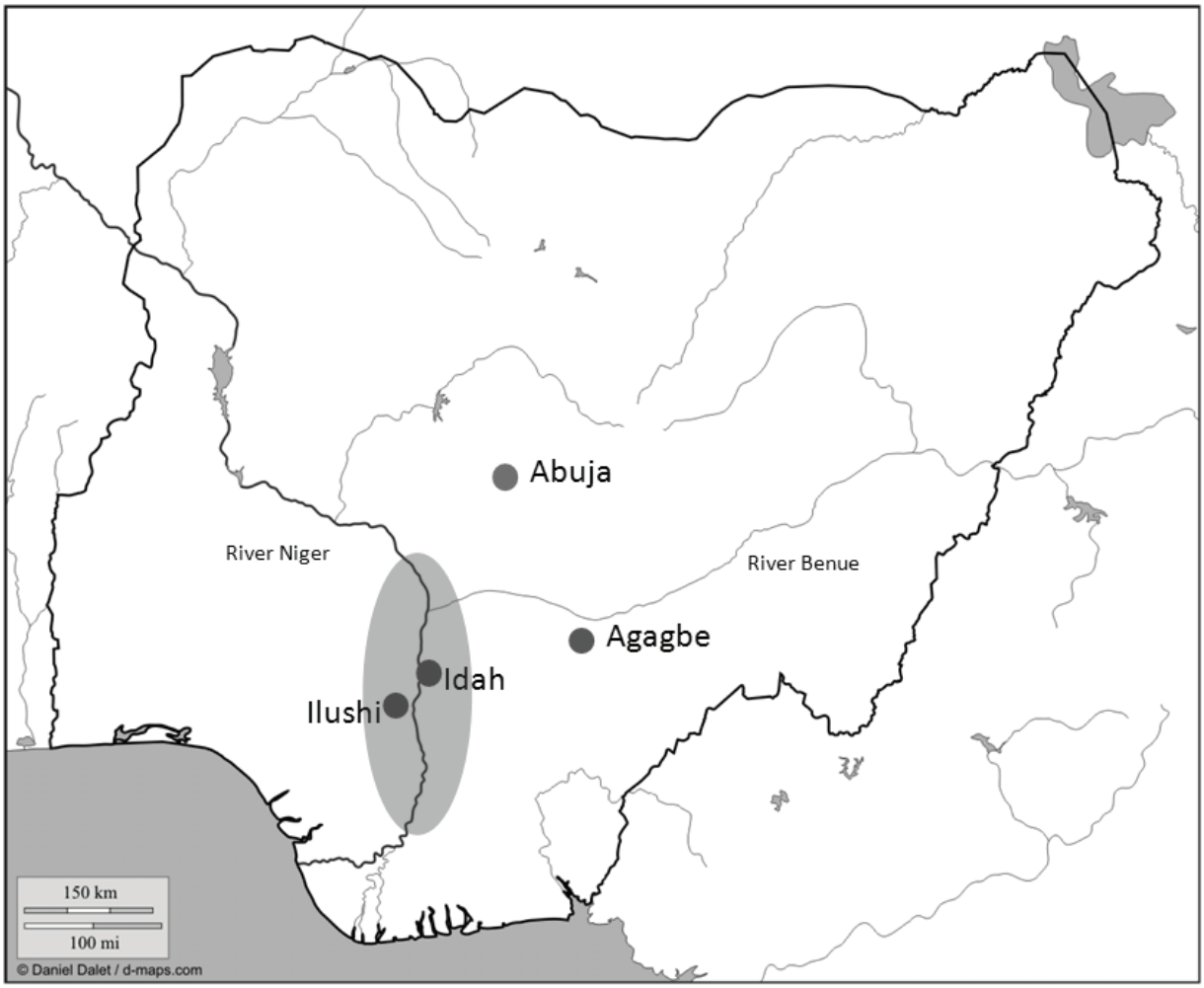

Figure. 2. Areas for promotion of AYMT in Nigeria via the YIIFSWA project.

This working paper will briefly set out the rationale for the AYMT and how it evolved from the YMT. While the AYMT was designed to overcome some of the issues identified by farmers with regard to the YMT there are nonetheless important repercussions emerging from this in relation to tuber size harvested and the use of pesticide. This working paper will briefly summarize some of the agronomic benefits of AYMT but the main focus will be upon the mode of promotion of the approach within the YIIFSWA project and the influence of local factors at play in the FCT and Niger River basin systems. The intention of the authors is to share some of their insights regarding the methods they have adopted in promoting AYMT and the challenges they face. Bringing any new agricultural technology to the fore is not an easy process and promotion is no guarantee of success; as will be seen with the YMT. The AYMT has so far received nothing like the promotion enjoyed by YMT over 30 years in Nigeria, but there are lessons nonetheless that can be learned from this experience.

2. Seed yams

Yam tubers (Fig. 3) are botanically speaking “stems” rather than roots and so have “buds” (called “eyes”) that contain meristematic tissue able to sprout and grow a new vine. Normally the “eyes” are kept dormant by the apical meristem, but if this effect is removed, for example by cutting the head off the tuber, then the eyes can sprout.

Figure 3. Yam tuber showing the “head” and the “eyes”.

Farmers have long known that tubers that have been cut into pieces (setts) can germinate and produce a new yam plant and indeed this is an important approach farmers are taking to produce their planting material. However, much depends on the size of the sett that is planted to produce a new yam plant. There are basically three important concerns here:

1. The sett must have at least one “eye” for it to germinate.
2. The larger the size of the sett the greater its chance of survival once planted.
3. The larger the size of the sett then the larger the size of the tubers that will emerge from the new yam plant.

The third point is especially relevant as it allows farmers to control the average size of tubers that will emerge from planting setts. Indeed if the size is just right then the resultant tubers would be small enough to act as “seed yams” (note that these are not botanically “seeds” but are small tubers). Planting whole tubers rather than setts provides benefits in terms of survivability once planted. Once a tuber is cut the surface becomes exposed to pests and diseases which can have major impacts on both yield and quality of the resultant tubers. Planting intact (whole) tubers reduces this risk.

Figure 4 provides an outline of the various approaches taken to the production of yam planting material—from setts to seed yams. The starting point at the top of the diagram is represented by large “whole” tubers (mother yams) and the flow from the top to the bottom represents the various stages that can be followed to generate new “ware” yams (i.e., large yam tubers consumed as food). As can be seen in Figure 4 a number of techniques have been employed to generate seed yams, usually starting with healthy ware yam tubers of medium size (~1 kg). Some of the techniques, such as the use of microsetts of 6 to 10 g, developed under “research station” conditions, have not found their way into farmers’ fields to any significant extent. But the two shaded boxes in Figure 4—the use of minisetts (YMT) and adapted minsetts (AYMT)—have been promoted to farmers in West Africa as a viable means for them to generate seed yams. Indeed the YMT in particular has been promoted since the early 1980s in Nigeria by a wide variety of government, nongovernmental, and private institutions.

The generation of the planting material in Figure 4 can also be applied with the use of pesticides to help survival and growth. This is especially important for the techniques that involve cutting yam tubers, but even seed yams benefit from pre-planting treatment.

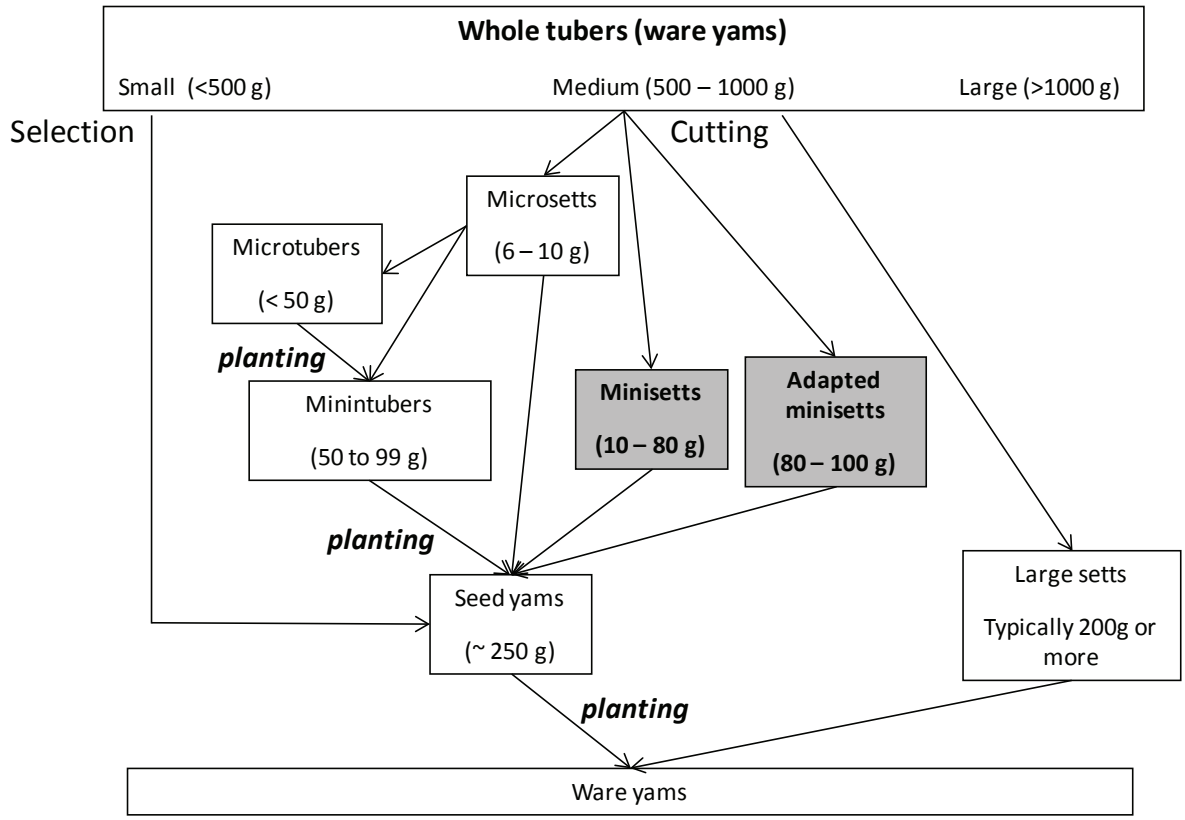

Figure 4. The spectrum of approaches that have been taken for the vegetative reproduction of yams.

3. Comparing AYMT and YMT

YMT uses mother yams of 500 to 1000 g to generate minisetts by careful cutting. Minisett size can vary between 10 to 80 g, but the recommended weight in Nigeria is 25 g (Kalu et al. 1989). One 500 to 1000 g mother yam should yield about 20 to 40 minisetts of 25 g and thus in theory YMT could increase the multiplication ratio in seed yam production from the usual value of 1:8 to a much higher value of 1:30 and help to reduce the cost of seed yam production. Minisett size is an important variable as the larger the size then the fewer the number that can be obtained from a mother yam, but at the same time the larger the minisett then the larger the seed yam tuber that is produced. An increase in sett size increases the yield of seed yam but also increases the average size of the seed yams, and at higher sett sizes the yield contains a sizeable proportion (~30%) of ware yams. The 25 g recommendation was meant to be a compromise between these competing requirements of maximizing setts from a single tuber and the need for a reasonable proportion of seed yams in the yield (Kalu et al. 1989), although others have pointed out that larger minisett sizes than 25 g would be better (George 1990). However, the relationship between sett size and resulting yield of seed yams as well as their size distribution can be influenced by a number of other factors, and this is still poorly understood.

Following cutting of mother tubers into minisetts the recommendation is for farmers to allow the cut surface to “cure” (dry and harden) in a warm but humid location, ideally with the aid of a wood ash treatment to help dry the surface. After this the setts are treated with a cocktail of insecticide and fungicide applied as a dust or a “dip” (Okoli 1986; Igwilo and Okoli 1988; Kalu et al. 1989). Wood ash is also claimed to have some pesticide effect (Otoo 1992), although its effectiveness has been described as variable (Onwueme and Charles 1994). Although the treated minisetts can be directly planted into the field, it is usually recommended that they are first pre-sprouted in a nursery before transplanting. Pre-sprouting in a medium free of pest and disease can help minisett survival, but it is more labor intensive (Okoli 1986). Sprouting time and indeed sprouting rate (percentage of planted setts that sprout after a defined time period) can vary between varieties (Igwilo and Okoli 1988).

Sprouted minisetts are transplanted in the field after the rains have become established at a typical depth of 9 to 12 cm with a plant spacing of approximately 25 cm (4 stands per m^2 if meter ridges are used = 40,000 stands/ha). In general, higher plant densities tend to give smaller seed yams (Osiru et al. 1987). Mulching with dried plant material or even plastic sheeting, has been recommended to reduce water loss and to provide some weed control. However, in practice farmers will tend to “cap” planted setts with dead leaves and straw held in place by a piece of soil. Establishment in the field can take 4 to 8 weeks (Okoli 1986), depending upon local environment, variety, and minisett size, and the vines require staking for best results although farmers often do not practice this with seed yam, preferring instead to let the canopy close and hence shade out weeds. Mulching and staking together can have a marked effect on the yield of seed yams from minisetts.

While the YMT has its benefits in maximizing the multiplication ratio it does have some significant drawbacks that have not helped its adoption. Estimates from adoption studies (proportion of farmers practising it) have suggested that adoption of YMT is at most approximately 50%, although “adoption rate” is usually defined in terms of those farmers adopting YMT once they were aware of it. Indeed there can be some ambiguity as farmers may adopt the technique for a period before abandoning it. The results of various studies suggest that there has been no improvement in adoption rate in YMT

over the 10-year period between 1991 and 2001, and if anything there has been a decline. However, these figures are average adoption rates and can hide significant local variation. For example, Okoro (2008) suggests that only 47% of respondents on average to a survey in the yam belt of Nigeria (18 states and 1677 respondents) had heard of the YMT while adoption of the technique was 22% on average. But the average adoption rate of 22% hides a large degree of variation between the 18 states included in the survey. Kogi State, for example, had an awareness rate of 90% and an adoption rate of 60%, while Edo State had an awareness of just 6.5% and an adoption rate of 3%. For those farmers who had some awareness of the YMT, this came mostly from extension agents (45%), as one would perhaps expect, but was closely followed by friends and neighbors (39%). However, even here there may be some ambiguity as the YMT was initially based upon traditional practices found in some parts of Nigeria. Various reasons have been given for the relatively poor adoption of YMT, especially given the substantial promotion of the technique that has taken place in Nigeria over several decades and by a number of agencies, and the reasons given by farmers for non-adoption can be numerous and vary from place to place.

Figure 5. Cutting the yam setts.

The AYMT was designed to address some of the reasons that farmers have claimed for non-adoption of the YMT. The major changes are twofold:

1. Increase in sett size over that used in YMT.
2. Use of a pesticide “dip” treatment instead of dust.

The AYMT uses a larger sett size (80 to 120 g), planting directly into the field rather than using an intermediate nursery stage as in YMT. This does mean that a single mother tuber generates fewer setts and hence seeds with AYMT than YMT; the removal of the nursery stage more than compensates for this. Not only did the small setts in the YMT require a nursery stage, hence increasing labor requirement, but the sprouted setts were regarded by farmers as being more vulnerable when planted into the field.

In AYMT, as in YMT, it is important to begin with mother tubers of around 1 kg in size and which are clean (i.e., have no visible signs of disease or pest attack). The setts are produced (Fig. 5) using a sharp and clean knife and the results are shown in Figure 6.

Figure 6. Minisetts produced with the AYMT.

The second consideration of the AYMT is the use of a pesticide dip rather than dusting. It could equally be possible, of course, to use a dip within the YMT and so this can be regarded as an improvement in itself rather than being specifically tied to the AYMT. The recommendation for the pesticide dip originally developed for the AYMT involved two pesticides:

a. Insecticide (chlorpyrifos) which prevents soil pests (insects and nematodes) from damaging the setts.
b. Fungicide (Mencozeb) which prevents the fungi that cause decay from attacking the setts.

There are various formulations (types) of these and the ones employed in the demonstration plots during 2012 and 2013 were Act Force Gold (insecticide) and Z Force (fungicide). The recommendation is to add 100 mL of Act Force Gold (the insecticide; contains 45% of chlorpyrifos) and 100 g of Z Force (the fungicide; contains 80% of mancozeb) to 10 L of water and stir. The best way to make up the dip is to first add the required amounts of pesticide to a few liters of water, and stir before adding the remainder of the water taking care not to splash it onto the body. This allows for a thorough mix and also reduces the risk of any neat pesticide splashing from the surface of the water onto the skin and eyes. Thus two containers are necessary—one for the mixing of the pesticide dip and one for holding the water. The container that holds the dip must be big enough to ensure that the setts held in the dipping bag can be placed under the surface without any of the dip coming out of the container.

Once the dip has been produced the yam setts are put into a filtering net sack made of an old mosquito net or perhaps an old sack with lots of small holes (Fig. 7). It is important not to overload the sack and all must fit into the container holding the dip so that all setts are well below the surface. The setts are then placed into the dip for 5 to 10 minutes. When ready the setts are removed from the dip and excess liquid is allowed to drain from the sack. The treated setts are then spread out on a surface to dry. If a second sack is available then that can be filled with untreated setts and dipped or if only one sack is available then it can be refilled with untreated setts and the process continues.

Figure 7. Dipping the yams setts.

After dipping, the treated setts are placed onto clean level ground free from dust (Fig. 8). The setts are spread so that the cuts are facing up and they are left to dry (cure) for about 4−5 hours. It is important to avoid direct sunlight but also, of course, to make sure that the setts cannot be eaten by animals. They must be well out of reach of children. Treated setts should be planted within 3 days to avoid overdrying.

The treated setts are typically planted in a meter ridge at a spacing of 35 to 40 cm (skin side facing downwards). Some farmers prefer to use a spacing as high as 50 cm. Much depends upon the type of soil.

Figure 8. Treated yam setts left to dry.

In theory the use of a pesticide “cocktail” dip has the following benefits:

- Better penetration of the flesh of the sett by the liquid. The use of dust formulations means that the pesticide tends to remain on the surface of the sett.
- Provide a more targeted application as there is less potential for loss of pesticide within the soil environment relative to surface dusting where there may be some “wash off” following rain.
- Safer as there is less manual handling of pesticide. In the experience of the authors farmers typically use their bare hands to apply dust formulations to setts.
- More choice for farmers as emulsifiable concentrate (EC) and wetable powder (WP) formulations of suitable pesticides are more readily available than dust formulations. EC and WP formulations are also less bulky to transport given their more concentrated form compared with dust formulations designed for seed treatment.
- Less reliance on pesticides that have longer persistence in the soil. The YMT tended to rely on the use of products such as Aldrin and Lindane, perhaps combined with wood ash. With the liquid cocktail far less persistent pesticide such as chlorpyrifos can be employed.

There are caveats:

- Waste pesticide liquor has to be disposed of and the best method of doing this is by burying. But this can at least be concentrated in one spot.
- While in theory it should be safer as there is less chance of the farmer coming into contact with the pesticide this is based upon anecdotal evidence (observation) rather than empirically derived data.
- There is always the danger that liquids may penetrate the skin more readily than the dust formulations and the concentrated form of EC formulations certainly does make them more dangerous if accidentally ingested. Adhering to appropriate health and safety regulations should minimize this eventually (please see the earlier directions regarding AYMT preparation).

Given these circumstances, the AYMT sought to address only a few of the challenges experienced from the farmer’s point of view and is not a panacea. It still has the disadvantage of not removing viruses from the seeds produced. Also, it still requires labor and some expenditure by the farmer, although this does have to be weighed against the cost to the farmer of sourcing seed in other ways, including traditional methods such as milking.

4. Promoting AYMT

In YIIFSWA the key to the promotion of AYMT is no different to the approach taken with a host of other agricultural technologies—demonstrate them to the farmers and see how they respond. There are two aspects to this simple approach. Firstly the demonstrations can be owned and managed by a number of key farmers and their households. They gain hands-on experience of the technology and can adapt it as they see fit. Secondly, a number of other farmers can be invited to observe some of the activities in the AYMT demonstrations. This greatly expands the number of people who can see the technology even if they have no opportunity to engage in a more direct sense.

The Missionary Sisters of the Holy Rosary (MSHR) has much experience of working with farmers to establish demonstration plots and associated training and visits. Indeed it has been engaged in such work since the 1970s, and was one of the first organizations in Nigeria to promote the YMT in the early 1980s. MSHR knew it was necessary to avoid a one-size-fits-all approach and therefore opted to establish a range of demonstrations designed to meet a variety of farmers' needs. Some of the latter, known as "early adopters" of technology, are willing to take risks while others require more convincing before opting to adopt on a larger scale.

In 2012 MSHR began the program with a total of 27 plots split between Idah, Agagbe, and FCT as set out in Table 1. Unfortunately 10 of these sites, all in the Idah area, were lost to severe flooding of the River Niger that year, but even the plots that were lost still had some value in terms of farmer training.

The entrepreneur and core sites in 2012 (Idah and Agagbe) consisted of 10 m × 15 m plots, divided into two equally sized areas: one with treated setts and one with untreated setts. The idea was to demonstrate the value of the pesticide treatment as well as provide experience for them in terms of the method of application. The use of a pesticide dip was a new departure for these farmers as they were more used to dust formulations. The farmers were also expected to complete a business plan.

The only difference between the entrepreneur and core sites was in terms of future engagement of the farmers. The entrepreneurs agreed to remain in the program over the 5 years, while the farmers involved in the core sites were free to engage in AYMT as a one off and were not expected to take part in subsequent years unless they so wished.

The small sites in Idah were 10 m × 10 m and all of the setts were treated. The idea here was to engage farmers who had little knowledge of the AYMT and indeed may not be all that aware of the much older YMT. All setts were treated as part of the demonstrations and training with engaging farmers. Many farmers were invited to attend to experience the training and demonstrations first

Table 1. Number and types of demonstration in 2012 along with the number of farmers trained.

Type of plot	Location	Plots established (no,)	Lost through flooding of the Niger (no.)	Farmers trained (no.)
Entrepreneur sites	Idah	6	2	265
Core sites	Idah	10	7	868
Small (inducement) sites	Idah	4	1	1299
Core site	Agagbe	1	0	400
Core sites	FCT	6	0	1904
Total		27	10	4735

hand; exposure to the training was an opportunity for them to evaluate the technology and its appropriateness to their situation. A well-trained agricultural extension worker was responsible for the training.

It was necessary to take a different approach for the FCT given that this area is far more developed than the Kogi and Benue areas. The FCT has well-established and supported groups of farmers, many of whom had been involved in research projects that preceded YIIFSWA and from which the AYMT evolved. Introduced via the government-funded Millennium Development Goals (MDGs) Office in Abuja it was a relatively straightforward process. Conditions in FCT are ideal as the extension networks in place are excellent in a major and wealthy metropolitan area; it has markets within easy reach of the farmers which in itself is a significant inducement to aid adoption of technologies that can boost yam production. The MDG office in the FCT is very active with strong links to local extension services and community groups. Abuja also has many commercial banks that can provide financial support to farmers. Thus the institutional structure for promotion of AYMT (the “push”) is excellent and there is a strong “pull” from the presence of a large and relatively wealthy market.

In the Niger yam production zone, of which Igalaland is part, matters are very different, and here there was reliance on an NGO called the Diocesan Development Services (DDS). DDS has been involved in rural development in the area for over 40 years. There has been a special relationship with yam as the Niger/Benue is said to be the center of domestication of D. rotundata and it is here where one may expect to see the greatest genetic diversity. Many farmers approached DDS complaining about the loss of many of their best-liked yam varieties. This was mainly due to declining soil fertility in the plateau area of Igalaland; soilborne diseases were common. Initial research funded by DFID and Irish Aid in 1993 and 1994 examined problems in storage and following this awareness, campaigns took place on the care needed to be taken during harvesting and when transporting yams. Despite many efforts to assuage the problem, yam production was on the decrease. Further research in 2002 to 2005 showed that scarcity and high cost of seed yams was a major constraint and the AYMT evolved from this.

It was decided to establish 6 sites in the FCT, with areas planted to untreated and treated setts. The number of heaps planted to treated and untreated setts was left for the farmers to decide rather than prescribed as in Idah and Agagbe, and could, if they so wished, have a larger area and indeed one opted for 800 heaps; 600 planted to treated setts and 200 to untreated. A number of groups also opted to plant setts derived from yam tubers harvested from clean seed yams harvested in 2011. The latter were part of the DFID-funded research mentioned above that helped to create the AYMT.

All participants used household and hired labor for cultivation of their farms. In the FCT there is some use of tractors for land preparation, but for farmers in the other states all activities, including land preparation, are manual.

MSHR began with the establishment of 27 plots in 2012 and were fully aware that a greater number of plots were possible. The limiting factor was not farmer interest—indeed far from it—but sourcing the inputs. In 2013 MSHR was compelled to increase the number of demonstration plots and farmers trained. A summary of the relevant numbers is shown in Table 2. This was made possible by enthusiasts for a program that took income, improvement, and food security as key foci, therefore they rode in to highly subsidize the intervention.

Table 2. Number and types of demonstration in 201 3 along with the number of farmers trained.

Type of plot	Location	Plots established (no.)	Lost (no.)	Farmers trained (no.)
Entrepreneur sites	Idah	12	0	575
Core sites	Idah	30	0	4727
Small (inducement) sites	Idah	40	0	3114
Core site	Agagbe	1	0	267
Core sites	FCT	42	1	3,116
Total		125	1	11,799

While the types of plot were the same as for 2012 their design was different. The 2013 entrepreneur sites in Idah were 20 m × 20 m and only one row was planted to untreated setts; the other 19 rows were planted to treated setts. Most of the entrepreneurs were the same as those of 2012. Indeed three of the entrepreneurs from 2012 wanted to expand their AYMT production and were allocated two plots of 20 m × 20 m each. It was not necessary to demonstrate the advantages of the pesticide treatment as these participants had already seen and understood the effects of the treatment. The one row of untreated setts was kept purely as an internal check and also, more importantly, to provide some comparison for the farmers who visited the site during training. A business plan was an essential requirement for the entrepreneurs.

The Idah core sites in 2013 were 8 rows (ridges or rows of heaps) by 13 m in length. One row was planted to untreated setts for the same reasons as given above for the entrepreneur sites. No business plan was required. Some of the 30 farmers involved in core sites in 2013 were involved in core and inducement sites in 2012. Even if their plots were lost to flooding, they had witnessed the technique in action and recognized the benefits. The Agagbe site in 2013 was also called a core site but was 20 m × 20 m, of which 5 m × 20 m was planted to untreated setts.

The Idah inducement sites were 8 rows by 10 m and as in 2012 all setts were treated. On balance it was considered that the need to demonstrate the benefits of the AYMT for these farmers outweighed the need to include an internal check and comparison for visiting farmers. It must be remembered that so many farmers had no prior experience with AYMT or even YMT, and many of them were not involved in the 2012 program. Hence the challenge of setting up demonstrations with an untreated row is greater than with the more “experienced” (in AYMT terms) farmers engaged with the entrepreneur and core sites. Thus, in the 2013 season there was a general decline in the use of untreated setts for comparison.

The ethos for the FCT demonstrations remained much the same as in 2012, with farmers given flexibility with regard to plot size and the numbers of untreated and treated setts that they wished to plant.

In the 2012 season no attempt was made to consciously catalog plots in relation to the yam variety chosen by the farmers. This was mainly due to the pressure of getting the program off the ground. But in 2013, following discussion with farmers, greater attention was given to choice of variety. The experience in Kogi was that the two varieties chosen by farmers were “Ekpe” and “Opoko”. They see the varieties as having quite different characteristics. Opoko is a relatively soft tuber that is easily pounded and is described as “sweet” (i.e., has a good taste). Ekpe, on the other hand, has a stronger (harder) tuber but is seen as being high yielding and stores well. The use of only two varieties in Igalaland during 2012 and 2013 is not representative of the many varieties that farmers plant, but it is a start. Farmers in the FCT have continued to opt for a single variety–Meccakusa. The name implies tha the growers of the variety have an early opportunity of going to Mecca.

5. Promoting AYMT–some reflection on targets

The 2013 program was certainly ambitious and in retrospect it was perhaps too ambitious as reflected in the inadequate funding provided by YIIFSWA. This meant that funding had to be sourced from elsewhere, entailing much work and the stress that accompanies such undertakings. The results compensated as these were greater than our wildest dreams—both in terms of number of plots established and number of farmers trained. Given this, it is worthwhile adding a few reflections on targets. YIIFSWA is by no means unique in setting targets and milestones (time-bound achievements) for its various activities. These are necessary in order to ensure a project achieves what it set out to do and in a reasonable (for participants as well as the funder) timeframe. MSHR was expected to achieve the targets shown in Table 3 over the life time of the YIIFSWA project.

Table 3. Targets set out for MSHR in terms of the number of farmers to be trained in the AYMT.

	2012	2013	2014	2015	2016	Total
Number of demonstrations	15	15	15	15	15	75
Number of farmers trained/year	3000	6000	6000	6000	6000	27,000

MSHR was also contracted to help establish 10 specialist seed yam entrepreneurs over the life time of the project. However, the irony is that MSHR has already exceeded (by a factor of two) the number of demonstration plots to be established over the life of the project; so far 152 plots have been established in 2012 and 2013 compared with a 5-year target of 75. With regard to the number of farmers trained, this reached 16,534 by the end of 2013; some 61% of the target figure. Why has progress been so rapid? The answer to this question is quite simply the interest of farmers. Indeed in both FCT and Kogi State the dominant problem faced by MSHR has been how to satisfy demand for demonstrations, and which resulted in a number of difficult decisions. Management of expectations is one of the major challenges of working with farmers–trying to respect these but within reason. If project leaders are not careful, prudent, and engaged in dialog with beneficiaries then confidence is undermined, trust can be lost, and the experience potentially detrimental to the program.

MSHR attempted to manage the demand by successfully sourcing additional funds in both 2012 and 2013, but especially in the latter year. This was possible partly because of the focus of the project on improving income and food security, and allowing a total of 125 plots to be established. In effect, MSHR has been able to subsidize the project to the tune of 200%. While great news for the participants and YIIFSWA as a whole, the irony is that the establishment of such a large number of plots and farmers trained has resulted in the five-year target figure of 75 plots being exceeded in just two years, and the target for the number of farmers trained being well over half-way to the final target of 27,000. This suggests that the targets underestimated the likely and lively interest shown by farmers based upon experience in the preceding DFID seed yam projects. MSHR was certainly aware that the level of farmer interest would definitely be high. A very important factor in relation to targets and methodology to achieve them is the focus on improving income. The problem of capital accumulation is ever present and the difficulties of obtaining loans at the commencement of each planting season at an extortionate interest rate keeps farmers and growers in a state of perpetual indebtedness. The restrictions around loan refunds and especially the inability to refund on time

could take away from the potential of the AYMT to change the fortunes of participating farmers and growers. Entrepreneurs are singled out for special attention in this objective within YIIFSWA and are being given the training and skills to determine what is required to make seed yam production a profitable business. This is a major challenge.

It is worth noting that the project targets given to MSHR were expressed entirely in terms of numbers; number of plots to be established and number of farmers trained over five years. The assumption held by the project was quite simply that if the farmers were trained in AYMT then this would automatically translate into improved income and enhanced livelihoods. There were no targets set for MSHR in terms of showing that incomes had been increased, and indeed there was no component addressing the transition from seed yam to ware yam. The latter is important as it is with ware yams that farmers generate their best income; the clean seed yam is merely a means to an end. A very interesting phenomenon has emerged as none of the entrepreneurs is willing to sell their clean seed yams. Instead these are kept for planting as ware yams. Most of the farmers having core demonstration plots also have the intention of keeping their seeds for ware yam (land permitting). On closer examination it could be felt that the emphasis in YIIFSWA is somehow weighted in favor of food security which is laudable in many ways but falls short of the ideals in the innovative title of “Yam Improvement for Income and Food Security”.

For MSHR on taking a close and critical look at its participation in YIIFSWA it would safely say it is practically there in terms of the food security section; we now need to move out of that comfort zone and concentrate more on the “income improvement” dimension. That challenge is in the court of MSHR. As already mentioned there are no set targets for the entrepreneurs; there is no real base line or starting point here. The biggest breakthrough is with training in Business Planning where learning the mechanisms involved therein is making progress. This is being done with the “AYMT entrepreneurs” who may not yet be fully appreciative of the complete relevance of the exercise. However this necessary evil may be the turning point in translating improved technology into improved income. It is the view of the authors that any Business Plan needs to be given a clear sense of purpose. This exercise is by far the most difficult one in their experience, for they have for many years introduced and managed microcredit for the improvement of agricultural development. Thanks to this past experience they appreciate that the big advantage with YIIFSWA is that it is recognized that as of now the yam crop, be it in the form of clean seed yam or healthy ware yam, is the one crop that gives the best income consistently and is not subject to the fluctuations in market prices as is the case with cassava, maize, and beans etc.

A snapshot of the author’s experience is briefly analyzed here as it relates directly to training in Business Planning in the context of the DDS. The staff of the DDS have worked on many crops over the last 40 years and are conversant with and committed to sound agronomic practices such as site selection, crop rotation, plant density etc as well as the necessity for record keeping on germination rates, weighing at harvesting, etc. DDS through these committed staff operate a highly participative approach to farmer engagement—a fact recognized by target group who firmly believe that DDS is needs led. (Not all needs have been answered with the desired speed but it tries). Farmers and participants no longer tell DDS what they believe it might like to hear as there is now mutual belief in dialog using the reflection–action–reflection process. Many new crop varieties (NCVs) have been introduced into the area (Igalaland) in the past 40 years; recently a researcher when asked about the impact of these NCVs there, stated that he and his colleagues often wondered what would have

happened were it not for all the NCVs introduced in the 1970s and 1980s. They even wondered would they have survived the Structural Adjustment Programme (SAP) without such interventions. They noted improved nutrition especially for children and enhancement of the local food industry resulting in better quality products. Long-term investment in tree crops commenced as did the provision of basic infrastructure such as water, bridges, and culverts which helped mobilization of their farm produce and mobility in general. It also contributed to less strenuous work for women and children were not burdened with collecting water before going to school. Conditions have improved but have not yet radically changed. Capacity has and continues to be developed and it is crystal clear that this capacity development has to be around making sufficient money from a crop that best gives high, predictable, and constant income. This can be from both clean seed yam and ware yam. More importantly, perhaps, is the spirit of trust that pervades.

What has happened over the past 40 years tells us that change is possible and more success is on our doorstep provided the right approach is adopted. Old beliefs and habits can change even if incrementally. MSHR believes that it is now more ideally placed than previously due to YIIFSWA's objective of yam improvement for income as well as its previous experience in micro credit. In the current program there are no loans to farmers/growers. They are assisted with training and demonstrations on the production of the AYMT and supplied with the start-up setts. Oversight and training continues through the growing process. This paper bears witness to the amount of agronomic data that is becoming available in situ right now.

One might wonder why so much emphasis is placed on the business plan in the midst of agronomic data analysis. Perhaps this is fitting as it is the business plan that brings about the marriage of the technical, psychological, sociological, and economic that will eventually break the poverty cycle. All have to work hand-in-hand, purposefully, at the same time and in the same place at approximately the same pace. The authors feel that this is happening at the moment. The Peace Group in Gwagwalada near Abuja in the FCT (participated in the DFID projects) is an example even if the framers/growers there enjoy premier conditions not possible in Benue and Kogi.

What questions need to be answered now in order to get that sense of purpose mentioned earlier at the core of YIIFSWA action? In the authors' experience:

- No serious efforts could ever be made to plough back any profit into farmers' enterprises. First there were always unexpected deaths or illnesses for which anyone known to have made any money was called upon, be they family or neighbors. You expected to be cursed if you did not respond.
- School fees, uniforms, and books are now among the "musts" in practically all families.
- No definite figure could ever be put on the cost of food, clothing, normal health, and education expenditure. However, families could generally give an estimate for expenditure but never for income.
- Then there was the pressure from peers or neighbors to show you were better off by buying extra furniture or improvements generally as proof of your good fortune. The Protestant ethic and the spirit of capitalism were and are still unknown and would be difficult to practice. Indeed many improvements were badly needed and essential for wellbeing generally.
- There was always the possibility of resentment and sabotage would not be unknown.
- Problems of theft always reared their heads.

- But the biggest scourge was repayment of loans at high interest rates. No one ever referred to such issues when looking for help or considering the foregone. The cargo cult mentality and false expectations crippled possible progress.
- There was no real effort to plan for the next planting season and any savings set aside was for the ever occurring contingencies. Planning for such eventualities seemed to be tempting providence. Planning might be seen or experienced as countercultural.

The next section provides relevant and useful information from the current work on the business plan as revealed through the analysis of the work with the 12 entrepreneurs and from other researchers engaged in this work. This knowledge can now be put to work in the 2015 programs for Objectives 3.2 and 3.6. There are clear leads as to how to deal with points 7 and 8 through the business plan. Indeed provision can be made to plan for costs incurred for points 1 to 4 since families can have an idea of expenditure from previous years; if there is a policy of inclusion internationally YIIFSWA could be on the way to peace building which is fast becoming a cross cutting issue for points 6 and 7. Could a provident fund be included to cover point 8?

6. Agronomic Performance of the AYMT

To date there have been two years of AYMT demonstrations in Nigeria, covering the growing seasons of 2012 and 2013. Please note that these are farmer-managed plots, using local practices, and there was no interference from the team other than to provide the treated setts and to record the number of setts, planted, germinated, yield etc. It is possible, of course, that the farmers involved are doing things differently to what they would normally do with yam production given that they are learning and would also be aware that they are under a spotlight and their plots will be visited, but even so these results are probably a lot closer to the farmers' reality than would be found with similar plots located on a research station. Also, these are demonstration plots–not trials. The inclusion of untreated setts in most of the demonstrations was intended primarily to demonstrate the value of the pesticide treatment to farmers managing the site and those visiting. The assumption, of course, was that treated setts would provide benefits compared to untreated setts and "seeing is believing". Planting untreated setts also allowed a check on the quality of the site in terms of its pest and disease burdens. Hence if the harvest from a site was very low then one could check whether this might have been due to either poor application of the pesticide or the choice of a poor location. The intention from the outset was not to generate data for statistical analysis, and hence the design of the demonstrations was not geared towards generating data of significant quality to achieve this. If that had been the case then MSHR would, for example, have included plots of equal size for treated and untreated setts. However, as agronomic data (setts planted and germinated as well as number and weight of tubers harvested) were collected for each of the sites it is possible to generate some insights using the GLM approach to analysis of variance. In this section the results for 2012 and 2013 will be discussed within the context of a number of important (from the farmers' perspective) agronomic characteristics. These analyses do need to be treated with some care given the points made above, but they can still provide some clues with regard to the performance of AYMT.

Figure 9 shows the average germination rate for the sites in the 2012 and 2013 growing seasons. The bars are for untreated and treated plots, and the error bars are the standard errors based upon the error mean square of analysis of variance applied to the data. This is obviously an important characteristic for farmers as setts that do not germinate cannot produce anything. It is also the first visual indication that farmers have as to whether the AYMT is a success or not. Results suggest that the treated setts do germinate better than the untreated, as would be expected. But the good news is that even the untreated setts—those where the surface had been allowed to dry only before planting directly into the field—had an average germination rate of around nearly 80%. In 2013 there was no apparent difference between the two varieties Opoko and Ekpe in terms of germination rate.

The average tuber weight harvested from the YIIFSWA plots is shown as Figure 10. The difference between untreated and treated is again statistically significant, with tubers produced from treated setts having a higher average weight than untreated ones. There is no varietal effect evident in the results from 2013 but there is an interaction between treatment and variety; basically the Ekpe variety responded better to the treatment than did Opoko. This is an interesting finding, and does suggest that similar interactions may be seen with other yam varieties. Does it perhaps suggest that some varieties are more susceptible to pest and disease than are others? Farmers have often alluded to this and it would help explain the results, but there could be other factors at play such as varietal differences in tuber structure that have an impact on ability of pesticides in dip form to penetrate.

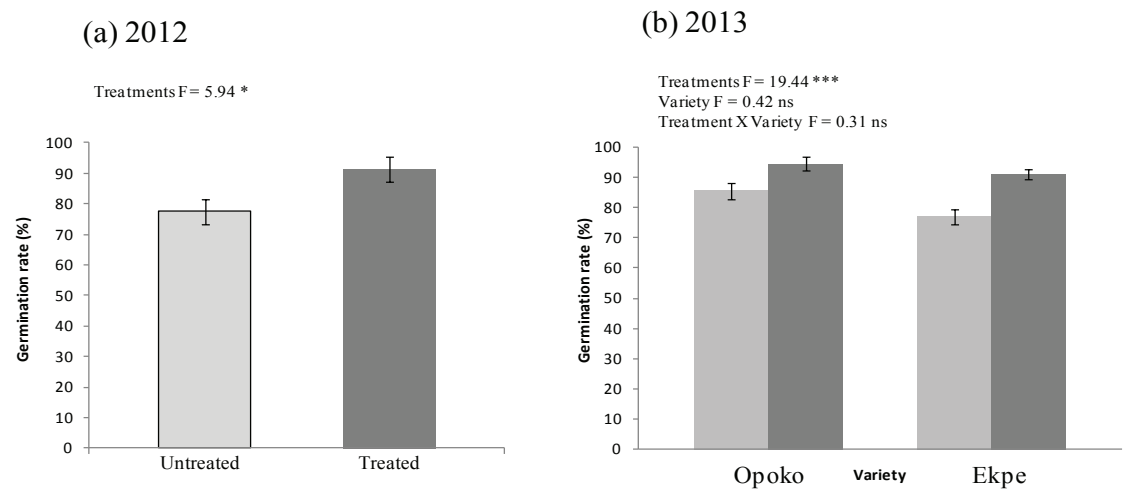

Figure 9. Average germination rate (%) for the demonstration plots in 2012 and 2013.

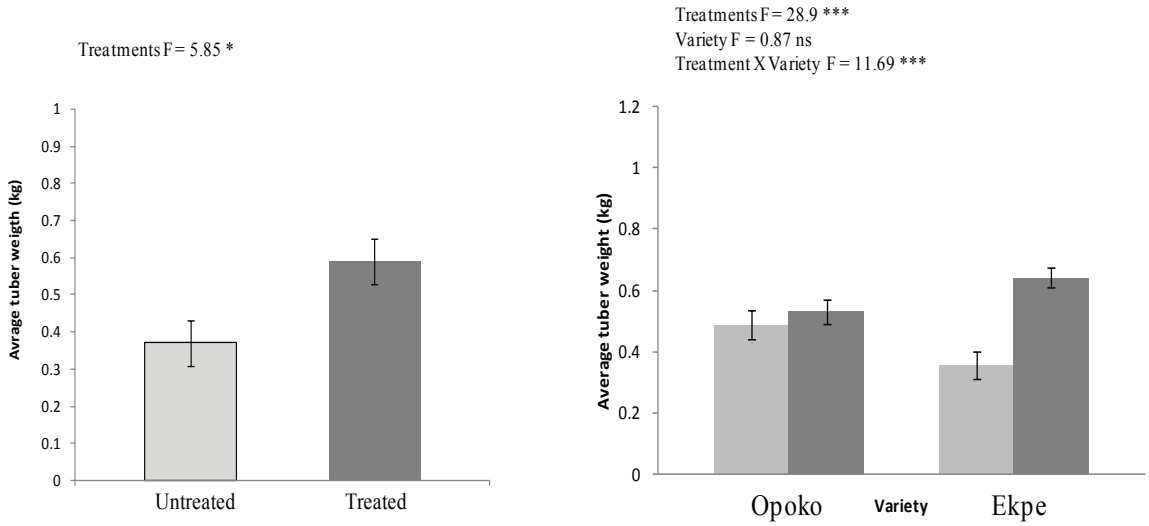

Figure 10. Average tuber weights (kg/tuber) for the demonstration plots in 2012 and 2013.

A further interesting finding from Figure 10 is the fact that the untreated setts had an average tuber size closer to the “ideal” for seed yam than the treated setts. Tuber size is a critical consideration in seed yam production, although the ideal size for a seed yam tuber is somewhat subjective and probably depends upon variety and farm location. Under local conditions the AYMT will generate a range of tuber sizes, and this will be influenced by sett size as well as the environment and management. One classification system for yam tubers based upon a number of papers is provided as Table 4. Here there are two grades of seed yam —Grade 1 is those from 0.25 to 1 kg while Grade 2 is from 0.1 to 0.249 kg. The upper end of the Grade 1 range begins to approach ware yam size (typically 1 kg or above), although even here farmers may well cut the tuber into larger setts for ware yam production. The “ideal” seed yam size is perhaps at the low end of Grade 1 and upper end of Grade 2 at around 0.2 to 0.4 kg.

Table 4. Yam tuber classifications based upon a number of sources (Ezeh 1991, 1998; Ikeorgu and Dabels 2005; Ogbonna et al. 2011a and 2011b).

Yam tubers	Category (g)
Ware yams	> 1000 g
Seed yams (Grade 1)	250−1000
Seed yams (Grade 2)	100−249
Mini seed yams (mini tubers)	50−99
Micro seed yams (micro tubers)	< 50

The average tuber weights in Figure 10 for both untreated and treated plots places them firmly within the Grade 1 band, but the averages do mask the distribution in tuber size (a variable not recorded) and this variable does have to be balanced against the better germination rate. It is certainly the case that participating farmers do not regard the average higher weight of tubers from treated setts as being a problem, far from it. The option to cut larger tubers into setts for ware yam has already been mentioned and at the top end of the scale there may even be some tubers that can be consumed as ware yams. Thus the farmer is given options with these tubers—some to keep or sell as seed yams, some to cut for ware yam production, and some to sell or consume as ware yams. The lower average for the untreated plots (0.4 kg) does mean that more of the tubers are likely to fall into the "ideal'"seed yam size category (Grade 2), but the trade-off is that there are fewer options open to the farmer.

Given that the treatment influences germination rate as well as tuber size then it is necessary to look at performance relative to setts planted and germinated. Figure 11 provides the number of tubers harvested and the average tuber weight per sett planted. The setts that do not germinate obviously provide no yield, so the result is a lower figure than the averages seen in Figure 10. But this is nonetheless an important variable for the farmer as setts planted are a cost to him/her in terms of planting material, land, and labor. The results suggest that the treatment increases the number of tubers and the average weight of tuber for every sett planted. This means the farmer gains more for the resource that he/she has invested. The interaction between variety and treatment was again evident from the 2013 results.

In relation to the number of tubers harvested/setts that had germinated the averages for untreated and treated plots are shown in Figure 12. This variable strips out the positive impact that the treatment had on germination rate. There is a statistically significant difference between the average for untreated and treated plots, but both are around one tuber/sett. The slight difference seen here between untreated and treated would, of course, be more important over large plant populations. The fact that the untreated average is less than one reflects the fact that some setts would only produce very small tubers and these would not have been kept at harvest. (This could have implications for women especially for both household needs and food for sale).

Overall the results suggest that the pesticide "mix" increases germination rate, average tuber weight, and yield (assessed in two ways). Unfortunately no assessment was made of tuber quality so it is not possible to say whether the increased yield also results in better quality tubers.

In terms of total clean seed yam production over the two years the figures (Table 5) are salutary. The impact of the severe flooding in 2012 is apparent in these figures for the Idah area; hence the relatively low production of less than 2 tonnes of clean seed yam for that year. However, in 2013 the activities undertaken in the three states have generated almost 27 tonnes of clean seed yams. All tubers were kept by participating farmers.

This level of clean seed production is impressive giving a taste of what could be possible if conditions continue to be conducive.

Table 5. Total weights (kg) of clean seed yams harvested in 2012 and 2013.

Type of plot	2012*	2013
Core (Agagbe, Benue State)	–	270.98
Core (Idah)	364.81	7,707.92
Core (FCT)	1093.9	3,459.50
Entrepreneur (Idah)	411.2	8,192.30
Inducement (Idah)	–	7,114.86
Total	1869.91	26,745.56

*The 2012 results were affected by the flood and some plots could not be harvested.

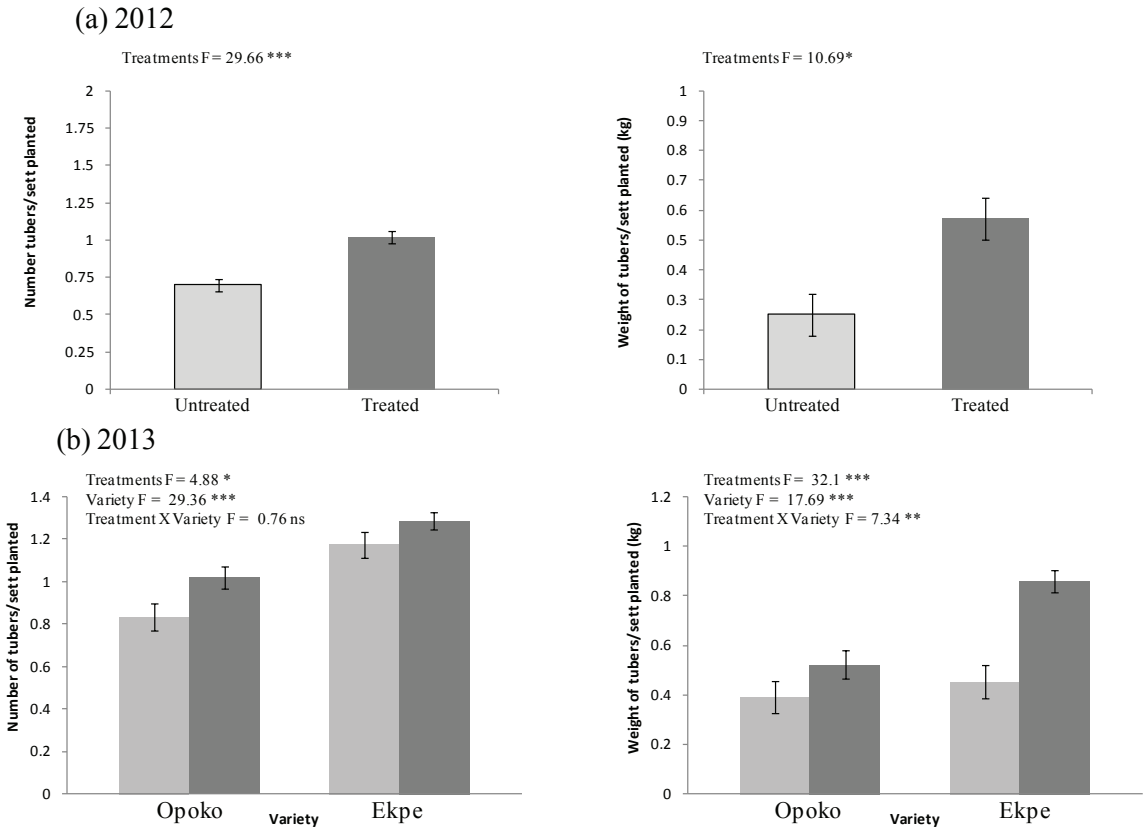

Figure 11. Average number of tubers harvested and average tuber weight per sett planted.

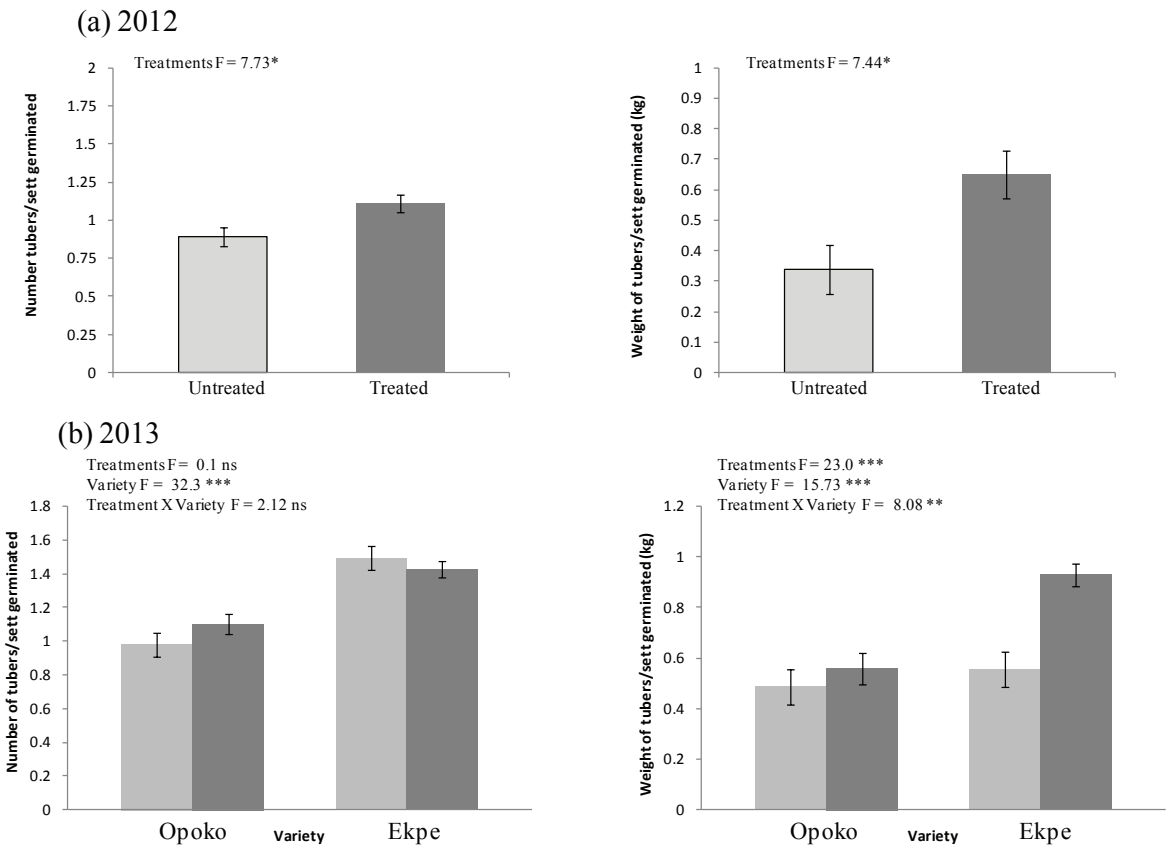

Figure 12. Average number of tubers harvested per sett that had germinated.

7. Economic performance of the AYMT

Work with the 12 entrepreneurs on their business plans in 2013 helped derive useful insights into the economics of the AYMT. It must be stressed that these plots are entirely farmer-managed ensuring costs are as close as it is possible to get to those other potential AYMT growers would face. But as with all small-scale farmers in Nigeria it can be a challenge to get figures that matter more to farmers rather than to researchers. In Igalaland what matters to farmers is the financial outlay they need to undertake when establishing an enterprise such as AYMT. The costs typically include planting material, staking material, herbicide, and labor. Much of the labor is provided by the farmer him/herself, usually with some input from the household; this is often not regarded as part of that financial cost although socioeconomic researchers typically try and impute such data using labor rates for the area. Hence it is important to differentiate between what the farmers perceive as costs, (and of course this is an important factor in driving their willingness to engage in AYMT), and what researchers would include. The latter is not necessarily the variable that farmers would see as important in their decision making. A further complication has arisen from the fact that all 12 of entrepreneurs have not sold their seed yams. All opted to keep their seed yam for planting as seed yam although some of the larger tubers were consumed. This makes it hard to estimate revenue. This practice of keeping seed yam to plant to ware is also practiced by the Peace Group in Abuja.

For the purposes of this analysis shown here the authors decided to work with the cost as realized (as seen) by the farmers. It does not include any attempt to cost household labor, but would include any money paid by farmers for hired labor. Secondly the revenue has been estimated based upon the known number of seed yams harvested (this was recorded for each site) multiplied by two estimations of the price that may be obtained for each tuber—namely N50 and N120—representing the estimates made by the farmers themselves. The results, means, and standard deviations for the 12 sites are shown as Table 6. These figures have not been extrapolated to the scale of a hectare precisely because it is the author's intention to show how these figures would appear to the farmers involved. Overall the results suggest a very healthy gross margin from AYMT and indeed an excellent return on investment (gross margin/cost) of between 158% and 520% (on average), although the standard deviations are admittedly quite large.

Nonetheless while there is some variation in the data it is easy to see why the AYMT is proving to be popular with farmers in Kogi State and why MSHR is having no difficulty in finding volunteers to participate in the program. Naturally it does raise an important issue with regard to availability of money to spend on the plot. An average outlay of N17,750 for a plot of 400 m^2 (0.4 ha) is significant. The typical salary in Igalaland is between N40,000 and 50,000, although this varies a great deal depending upon the employer and any performance related bonuses. Hence an outlay of just under N18,000 for such a plot is equivalent to approximately one half of a month's salary.

Table 6. Economic results from the 2013 Entrepreneur sites in Kogi State.

Number of sites = 12 and plot size = 400 m^2

Variable	Mean (Naira)	St Dev (Naira)
Actual cost	17,750	4219
Number of seed yam	871	251
Revenue at N120/seed	104,510	30,108
Revenue at N50/seed	43,546	12,545
Gross margin (N120/seed)	86,760	30,037
Gross margin (N50/seed)	25,796	12,883
% Return on investment (N120/seed)	520	224
% Return on investment (N50/seed)	158	93

While Table 6 is based entirely upon costs as experienced by the AYMT entrepreneurs, a record was kept of the labor input (paid or household) for each plot. Labor is obviously a major input into AYMT, along with planting material; it is certainly worthwhile exploring which activities demand the most labor. Labor studies for AYMT have already been conducted and published so the results presented here are not novel. Figure 13 presents the average (+ standard error) labor inputs (person hours/ha) across the 12 plots, and the "U" shaped pattern is a typical one for AYMT. Land preparation (clearing, removing plants, and ridging/heap making) is the activity with the largest labor requirement and after that there is a decline until harvesting. The latter activity can take much time given that the ground may be hard and there is understandably a concern around tuber damage while harvesting. But the figures here also include the labor involved in transporting the tubers from the farm to a secure place, a fact often ignored in research on yam production. Security is an important concern for households, and indeed the need of a secure means of storage can sometimes outweigh concerns over crop loss due to pests and diseases in storage. Consequently, tubers are usually stored close to the compound and often inside a room that can be locked.

Of the 12 entrepreneur's plots in 2013, six were planted in April, five in May, and one in June. Two were harvested in November 2013 and one in December 2013. Of the remaining nine plots, five were harvested in January 2014 and four in February 2014. Thus the favored months for planting were April/May and for harvesting January/February.

Note: Bars are the mean labor inputs per hectare (person-hours). Error bars are + Standard Error based on the error mean square from an analysis of variance.

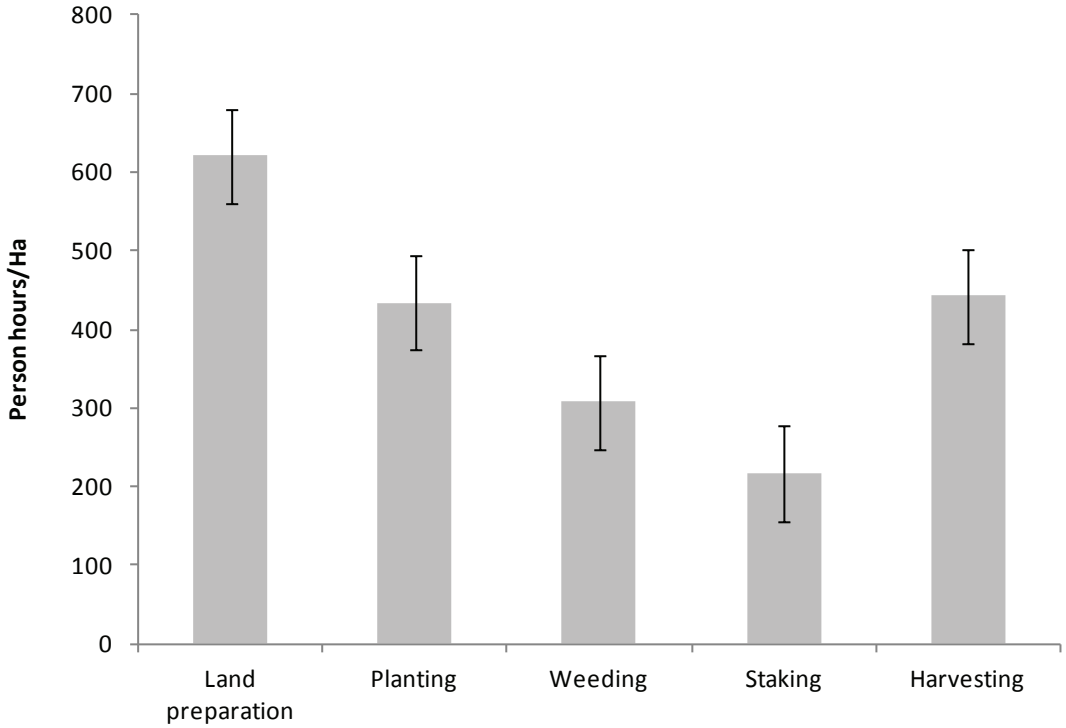

Figure 13. Labor inputs for the 2013 AYMT entrepreneur plots in Kogi State.

The timing of activities across the sites did vary and Table 7 provides the average timings and standard deviations. Three inputs of weeding were fairly typical, although some of the farmers did apply pre-emergent herbicide soon after planting which no doubt would have delayed the onset of the first weeding. Staking was often combined with weeding and for some farmers this activity needed to take place twice; the first time usually involves cutting and placing sticks next to the plants and the second may involve replacing/adding sticks plus some rope so the vines could spread laterally. It should be noted that the activities almost entirely take place in the first 5 to 6 months of crop growth. Harvesting took place between 8 and 9 months after planting. The farmers seem to have provided little in the way of labor input for the last 3 months of crop growth.

Table 7. Timing of farmer activities in the 12 entrepreneur sites of 2013.

Activity		Average (DAP)	St Dev (DAP)
Weeding	1st	61	27
	2nd	119	32
	3rd	164	24
Staking	1st	44	15
	2nd	67	18
Harvesting		250	26

8. Movement of pesticide from seed to ware yam tubers

All demonstration sites in 2012 and 2013 without exception produced some tubers large enough to be considered ware yam—a source of joy for female members who cooked them for the household. Is it any wonder that a frequently asked question is whether the chemical is still active in the flesh of the tubers after a season in the soil. After all, it should be remembered that the AYMT was designed to produce tubers that would be planted rather than consumed. Given that this pattern has emerged amongst the households it is worth further analysis. Chlorpyrifos, the insecticide used in the component of the YIIFSWA project described here, is assumed to be moderately toxic to humans with oral LD50 values as set out in Table 8.

Table 8. Oral LD50 values for chlorpyrifos.

Species	Oral LD50 (mg/kg)
Mice	60
Rats	95 to 270
Guinea pigs	500 to 504
Sheep	800
Rabbits	1000 to 2000

The question could be best answered by analyzing the flesh of tubers that grow from treated setts for chorpyrifos and its breakdown products. Unfortunately this not been done and indeed is an example where an emergence of farmer behavior runs ahead of technology promotion. Nonetheless, given that this behavior has emerged it is necessary to try and provide some answers even if only based on a more theoretical analysis.

A typical recommendation is to use 100 mL of insecticide formulation (45% EC on a weight basis) per 10 L of water. This volume of dip (containing 45 g of chlorpyrifos in total) should be enough to treat at least 100 setts (on average). Thus if it is assumed that all of the dip is absorbed by these 100 setts, an unlikely scenario, then each sett should contain 450 mg of chlorpyrifos. If it is then assumed that all of this finds its way from the sett into a tuber likely to be consumed by one adult then for an average human weight of between 54 and 83 kg this worst case scenario equates to between 6 and 8 mg/kg body weight; well below all of the mammalian LD50 values shown in Table 8. Hence a theoretical analysis of the use of pesticide dip does not raise any immediate concerns although the calculation does not, of course, take into account more chronic effects of such low levels of consumed chlorpyrifos, especially for children. However it should also be noted that:

- It is unlikely that all of the chlorpyrifos in the dip will be absorbed by the setts. Some waste is inevitable and disposal of this material needs to be handled with care as pointed out earlier.
- Chlorpyrifos does decay within plant material and yam setts remain in the soil for 270 days or so before harvest. The extent of this decay within planted yam setts is unknown, but a half-life in soil has been reported to vary between seven and 120 days. Whilst the rate of decline in plant material may be different from that in soil it is likely that by the time of harvest the 400 mg assumed to be in the sett at the time of planting would have declined significantly. Chlorpyrifos breaks down to 3,5,6-trichloro-2-pyridinol (TCP) and to diethyl phosphates.

- Chlorpyrifos is not translocated in plants and hence it is likely that the chemical will remain in the treated sett rather than find its way from the sett to the new tuber.
- Yam tubers are not eaten raw (of course) but are processed by households and this includes heating which is likely to degrade any remaining chlorpyrifos. Even the roasting of yam, the most basic form of preparation, exposes it to heat.

Given all of these points it is highly unlikely that the worst case scenario of 6 to 8 mg chlorpyrifos per kg of human body weight will occur. But even so this unintended response does raise questions that need further research.

9. Seed yam as a business; creative ways of making clean seed yam a life changer

This research undertaken in a number of DFID-funded projects had suggested that while the yam farmers in the Niger River system in particular were highly expert in what they did, they were reluctant to grow their own seed yam, preferring instead to purchase it each year from specialist seed yam growers. At first sight this tradition was an odd one. Production of their own quality seed yams would free them from the significant logistics of having to travel, by motorized canoe, down the River Niger to Illushi at the commencement of each planting season and home grown seed yam would in fact be significantly cheaper. Given their expertise the farmers were certainly capable of multiplying their own seed yam, although they did point to serious constraints of pests and disease which limited the quality of their seed. So what was the problem? Following extensive research it was found that the following issues were important brakes on change:

- Perceived risk. Igala farmers prefer to produce ware yams as this ensures a good market return and helps to guarantee food security for most of the year. Thus there is an immediate return on investment. The tradition gives security. The price per tuber for seed yam is lower than that of ware yam and, of course, the tubers are not as large.
- Familiarity. The sourcing of material from Illushi was ingrained and familiar, almost a social event. Despite their expertise in growing yam, an allocation of their scarce resource to seed yam production was a much more unfamiliar enterprise. In effect they had perfected the practice of buying from Illushi. They had identified risks such as robbery on the way to the market and Western Union transfers that were in use by yam buyers and sellers. But change had taken place as the composition of growers was changing. Part-time farmers and more educated farmers were entering the picture.
- Markets. Local Igala towns do not have a seed yam market of their own where farmers could sell. No local entrepreneur had managed to crack the problem of buying seed yams in bulk from Illushi and transporting them for re-sale in Idah. One of the issues here is the bulkiness (volume: weight) of the material that makes it inefficient to transport unless a truck is used and this is expensive. Thus while the cost of the seed yam transported in bulk this way would no doubt have been greater in Idah (to allow for the transport cost) the farmers may possibly have been able to save money.

These are not insurmountable issues, especially as the farmers recognized the problems involved in travelling to Illushi and the importance of clean seed yam. The latter was constantly referred to as the number one constraint in yam production. With this as a back drop, it was decided both in the DFID and subsequently in the YIIFSWA projects to introduce the AYMT as an alternative via a number of routes. Different categories of participating farmers and growers were identified and roughly divided into two broad categories of “innovator”.

1. **High innovators**. These were seen as entrepreneurs who would be willing to test the AYMT on scales that would be high enough to be apparent to the local community as well as providing a good return on investment. These farmers had been previously involved in the research and were well aware of the benefits—no need to prove the technology to them. Instead it was a matter of encouraging them to scale up to full-scale production to prove its economic viability.

2. **Medium innovators**. These farmers are open to the idea of AYMT and willing to give it a go but needed some convincing that the technique works at a technical level. Does such cutting of yam really generate seeds of the right size and quality? This question has to be answered before they can consider the economics of the process. It is still of import to first demonstrate to these farmers that AYMT can succeed in generating seed yams of the right size and quality. A few years on they can tell you the right weight, quality, and variety that suits best. A second category can be added here due to popular demand. Observers of the previous research aware of the limitations of the YMT wanted to try for themselves this new technology and have had to be included. “Doubting Thomases” and believers have all to be respected.

Within each category a number of approaches were tried. Within the high innovators’ category the plot size was of the order of 20 m × 20 m and all setts were treated. This group were also asked to adopt a business plan for their yam plot. The business comprised two main elements. Firstly the farmers were asked to outline what they anticipated as their costs, revenues, and gross margin; they were asked to identify all possible risks and how these risks could be managed in their seed yam enterprise. This was followed by the recording of actual costs, revenues, and gross margin as well as the challenges that they actually faced. The purpose of this is to encourage farmers/growers to visualize all that is entailed in clean seed yam production. This gives a realistic picture of what is possible, while at the same time providing a valuable set of information for the team leaders. Interestingly, at the time of writing (i.e., half way through the third year of the YIFSWA project) none of the entrepreneurs have opted to sell any of their seed yams. Instead they have opted to retain all for the next planting season.

Potential flexibility in the mechanics of the AYMT needs to be better understood. For example, in selection of a mother yam from which to obtain setts it is most profitable to have one weighing 1.2 kg from which 15 setts of 80 g can be obtained. If the ware yam is bigger than this then much of the flesh can be wasted. Spacing is also important as it determines the number of yams required; should it be 2 or 3 setts per square meter? Also of import when considering profit is the concentration of pesticide used for the dip, and the current recommendation is based on a “best guess”. But there has to be a balance between what works and also what reduces cost, and it may well be possible to reduce the concentration of pesticide in the dip and hence reduce both cost and risk. Labor is always the most costly element in any agricultural intervention, and weeding is one of the activities that ensures a good crop. While weeding is not the major labor input into yam, land preparation and harvesting are much greater sinks for labor; this can be reduced by the use of herbicide. A number of the farmers used herbicide on their plots and if there could be cooperation between participating groups to ensure that there is no waste of herbicide then this would be desirable, helping to reduce costs of chemical in particular.

The business plan approach adopted with the entrepreneurs has been highly satisfactory so far, although it did take time for the logic to be appreciated. Farmers that MSHR works with rarely, if ever, produce formal and detailed business plans. The AYMT is a reasonably well-known approach, although there are still important gaps that need to be closed. The challenge rests with converting all the technical knowledge into a cash profit for farmers. The business plan is a first step in that direction. However, in many ways this approach to planning is countercultural. Until now the participants in a project had to be seen to have cash which had to be shared and not accumulated. There was always the extended family, school fees, and so on that had to be addressed and which depleted capital

for investment in agriculture. The methodology adopted by MSHR has helped address this issue though of course each entrepreneur knows the value of their assets. Unexpectedly this is having a catalyzing effect in the communities as many now want to accumulate their capital, especially in light of the economic situation where pensions are not guaranteed. People are beginning to appreciate the need for a business plan. New paths of creativity are opening up with different forms of expression to help cope with the current societal problems. A new class has even emerged called the “coping class”.

However, it has to be said that introducing a business plan approach is certainly a challenge. It requires openness and transparency and an ability to set out one’s cost in an honest way along with the income. An ever-present challenge is that farmers are only too willing to list their costs, and talk at length and in detail about how high these are and how they are suffering, but far less willing to disclose their revenue. For the business plan to work it is necessary for both of these components to be presented, along with the risks and assumptions therein. Otherwise there can be no genuine learning from the experience either by the farmer or indeed by MSHR. It is essential for people to appreciate the values required for any major transformation to take place, but it takes time for thoughts to become patterns of behavior.

10. Vehicles for engagement with people

One of the interesting facets of the AYMT to date has been its relative popularity with farmers. The YMT has been heavily promoted over many years, especially in Nigeria, but the various adoption studies conducted since the 1980s have tended to provide mixed results. It did however keep the concept alive and farmers were exposed to it during field days and farmer training days. It may also have helped keep some endangered varieties alive and that in itself is a benefit.

The AYMT has to date not been promoted to anything like the extent of YMT so direct comparisons are impossible to make. However, based upon the experience of the authors there is no doubt that AYMT is proving to be more popular than YMT. A farmer who had been at many farmers' training days observed "that this [AYMT] has been made better now". This should not be too much of a surprise given that AYMT was designed from the start to address some of the problems with YMT expressed by farmers over some years, but to date the AYMT has been introduced only in a few parts of the country—most notably the Federal Capital Territory (FCT), parts of Igalaland, one village in Benue State (Agagbe), and one town in Edo State (Illushi). It is noteworthy that when the components of the YIIFSWA project described here were first introduced no farmers were practising YMT amongst the target groups.

Women in the Igalaland area of Kogi State traditionally did not engage in agriculture but with much encouragement for transformation this has changed and there are approximately 15% of women participants engaged in the 2013/14 trial . One of the reasons why extra funding was possible in 2013 was because of the participation of women in the program. This is also an enticement for them to engage in trading in seed yam and given there is only one seed yam trader to be seen in Idah it might be possible for them to blaze a trail here. Given that the Niger Benue river basins is the indigenous resource base of Dioscorea rotundata it is not surprising that there is dialog even if yet somewhat of a dream among the more innovative ladies to start a different business. Seeking cooked yam especially if home produced would also enhance income. There are already some useful hints doing the rounds among women. Just imagine you can get a mother yam of 1.2 kg that gives you 15 setts weighing 80 grams that gives you a good size ware yam. So from a mother yam costing N100 you can get you get 15 setts yielding at least 15 or 18 seeds (when treated) and a return of at least 18 good ware yams. That ware yam will certainly weigh in at 2 kg. The mathematics are being done and the practical work progresses. Some habits are surely being broken even if slowly.

The physically challenged have also been provided with opportunities especially in Benue and women now appreciate that it is cheaper to produce a basket of clean seed yam than a basket of poor quality yam. The dip's reputation for good quality seed is being broadcast at local level.

In 2014 women entrepreneurs are making their debut in Idomaland and that too will expand the knowledge as well as preserve more indigenous knowledge.

11. Discussion

The experiences to date (2012 and 2013) with the AYMT do suggest that it is a more attractive approach to producing clean seed yam than the YMT. Farmers, of course, do have other options for producing seed yam such as the cutting of larger setts or the use of milking. Development and enhancement of other technologies, such as micro-tubers, vine cuttings, and even the skins of yam tubers are still in development. Another option often talked about but so far under-researched is the use of tissue culture. The big advantage of tissue culture is that unlike many of the other techniques, the process can eliminate viruses from the planting material. All technologies have their own advantages and disadvantages, and it seems sensible to continue to take a multifaceted approach within research.

Unlike the YMT which had a large exposure through the various agricultural development projects in Nigeria as well as via federal and local departments of agriculture, the AYMT has not received similar promotion. So far this has been confined to the relatively small number of farmers involved in the DFID and now the YIIFSWA projects.

To date the results suggest that even the more risk-adverse farmers of the Niger River system are adopting the AYMT, although progress is slow. The notion of one-size-fits-all does not work and it has been necessary to adopt a diversity of strategies to accommodate the varying speed at which the farmers wish to work. In the FCT progress is much faster, but this is understandable given the local conditions. In all cases, the treated AYMT is distributed to participating farmers/growers. There are no cash transactions, a ploy which ensures that the leaders are free to concentrate on the technology. However, the business plans put a cost on each enterprise and each participant knows what he or she is worth. Yams and pesticides are given their correct value in the business plan and, of course, so is labor.

The AYMT was designed to help address some of the issues that limited the adoption of the YMT, so it is perhaps understandable that farmers would be more amenable to AYMT than YMT. It is also the case that the AYMT is successful in the sense of generating good quality seed yams. However there are many questions left unanswered that will hopefully be clarified during YIIFSWA. These include:

- Do the seed yams produced via AYMT give a benefit in terms of ware yam yield and quality? It is assumed that they do, of course, but empirical data are needed to prove that this is the case. Some experiments being conducted in the 2014 growing season should help with this.
- Do the pesticides applied in dip form linger on into the yam that is produced via the treated setts? This is important given that some of the larger yam tubers are consumed by farmers; an unintended outcome of the AYMT but given that some large tubers are generated one can imagine the temptation. As highlighted above (based upon the AYMT recommendation and what is known about chlorpyrifos) it can reasonably be assumed that the residue in any consumed yam grown from treated setts is minimal, if not zero, but data are needed to confirm this.
- Linked to points 1 and 2, is there flexibility to amend the pesticide recommendation to help make it more economic and also to reduce risk? The recommendation being used at present is a “best guess” developed during the DFID projects.
- Are the claimed advantages in terms of less contact with the pesticide and better environmental

impact really the case? The points made earlier in this paper are suppositions based upon what is included in the training, but does this practice hold true for what the farmers do?

- Can new markets emerge for seed yam nearer to the ware yam growers in Idah? There are hints that this may be happening but ironically an issue here is that all the seed yam growers in the Idah area retain their seed rather than sell it. Hence to date there have been only limited signs of a market for seed yam developing in Idah. However, a participant in the early research 2002 to 2005 is selling seed yam in his home town in Ekwuloko village which is a source of seed yam. In the FCT the farmers also retained their seed yams for ware yam production rather than sell them. Will this trend continue? This is indicative of a certain trend and may call into question (for some at least) the validity of creating entrepreneurs. Is capitalism being promoted when the trend is more towards self-sufficiency in seed yam among what are still resource-poor farmers? Or the question might be would it be better to promote room for both? Markets may indicate the demand and creativity may kick in.
- If the authors could have a wish in relation to this project it would be that all 27,000 participants would have a supply of AYMTs to help them be more food secure and so fulfil the first MDG making it a Sustainable Development Goal. The need and appetite is there so there is a plea for more funding with which to do it. But there are resource implications.
- The above development indicates that equality is being promoted—one of the major concerns of development world-wide. Now that it seems there is good reason to hope for more uptake with the AYMT than with the YMT is there another problem? Yes. Problems around land security and land grabbing are rearing their heads. Site selection can have many agendas. Is land selected and rented for yam production and other agricultural purposes done with a view to getting compensation for economic trees planted by those who rent?
- Will farmers/growers who are keen to make a living from AYMT be frustrated by land shortage or high rent just because they can produce a more productive crop on it? This is now a big problem for Africa and which may need to be addressed within the context of YIIFSWA also. Our attention is constantly drawn to the fact that some multinationals often have a prominent role in land which results in a western, private property system of land, that is not adapted to the African reality and which allows foreign investors to identify, negotiate, and buy/lease land easily. Cultural land is thus reduced to a tradable commodity.
- This project lends itself to social inclusion as women, widows, and the challenged are participating in growing numbers.
- Even though the 12 entrepreneurs were in place from the outset it is now time to give the extra concentration to the Business Plan. What are the financial demands of the household? List realistically what is needed. The wishlist syndrome may kick in but the experience from the Business Plan shows how fast this can be dissipated when the responsibility for improvement rests on your own shoulders. Once that realistic budget is planned what part can the Business Plan play? How much can you realistically realize in the short and long term? This adds a sense of purpose to your AYMT program even if it means much more time will be needed to concentrate on this for the next two to three years. This will not be at the risk of losing sight of the agronomic for that too requires more research. However, there will be much energy around that Business Plan in the hope that twinned with the ever improving knowledge about the AYMT it will become the lifechanger so much needed if that cycle of poverty is to disappear.

These questions are important for the success of the work being undertaken in the up-scaling work in YIIFSWA, and answers will no doubt be provided in due course. At present the signs are very encouraging but whether the AYMT will provide a sustainable alternative to the YMT is yet to be seen. There is one noticeable difference between the two in that YMT had enormous backing during the 1980s and 1990s by just about every agricultural development agency in Nigeria. AYMT has to date received nothing like that promotion and is unlikely to given the resources available for these work packages in YIIFSWA.

12. Conclusions

The AYMT has been shown to be a significant improvement on the YMT especially its acceptability by farmers. This is not surprising given that AYMT was intended to address some of the issues identified with YMT. The new technique is largely founded on some basic changes to sett size and insecticide treatment; the latter does have a number of positive impacts especially for germination rate, sett size, and yield. The promotion of the AYMT in conjunction with the business plan approach by MSHR and DDS helps with learning by all concerned. But there, a one-size-fits-all approach has to be avoided as farmers move at different speeds. Hence while some are comfortable with adopting AYMT on relatively larger scales others need to develop confidence by using smaller plots. However, one of the unintended consequences is that some households are consuming the larger tubers produced by AYMT and while in theory this should not be a danger given the recommendations in AYMT and the nature of the insecticide (chlorpyrifos) used in the technique there is nonetheless an urgent need for research to check residue (if any) and guarantee best safety practices. Stepping up on the energy around the Business Plan and encouraging more ways of making households economically viable will add fresh verve and color to YIIFSWA. MSHR and DDS are poised to do this as part of their mandate to reach the most marginalized, especially women, while being stewards of the environment.

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